Investigating relationships between flow, channel form, instream vegetation and ecosystem function

Healthy Waterways Strategy 2018-2028
Port Phillip & Westernport, Victoria

Melbourne Water

Strategic alignment

Regional Performance Objectives (RPOs):

- RPO 45: Research partnerships with universities and other research institutions are in place to address the key research areas and build our knowledge and capacity to efficiency and effectively achieve the HWS performance objectives and targets.

Key Research Areas:

- Vegetation and instream habitat: Improving our understanding of instream habitat conditions, threats and processes across the region to inform works planning.
- Hydrology and environmental flows: Improving our understanding of the responses of key environmental values to flow regimes to refine our environmental flow objectives

Summary

This research project has investigated how key aspects of the urban flow regime influence channel form and instream values; with a strong initial focus on instream vegetation. Understanding the establishment of instream vegetation and its current extent across the Melbourne Water network will facilitate the development of effective management strategies to protect and improve this key ecosystem value and stream ecosystem structure and function more broadly.

Research has shown that urbanisation drives increases in wet weather flows that lead to a range of stream health impacts such as increasing coarse sediment export and reducing organic matter storage, diversity and abundance of instream vegetation, and physical habitat complexity. However, we currently lack an understanding of which components of the flow regime are most significant at influencing sediment and organic matter dynamics and how they interact to influence instream vegetation, biodiversity and ecosystem function.

Instream vegetation provides habitat and refuge for in-stream biota, engineers biogeomorphic processes, increases hydraulic complexity, influences sediment and chemical fluxes and contributes to primary production in streams. Despite this, we know very little about its distribution and composition across greater Melbourne's waterways, major threats nor management opportunities. While vegetation in riparian zones, wetlands and lakes have been studied extensively, in contrast, knowledge of instream vegetation retention, germination, emergence, persistence and role as an ecosystem engineer remains poorly understood.

We surveyed 23 streams across the Greater Melbourne Water region and used these data to calculate geomorphic and flow metrics to identify relationships with instream vegetation richness, diversity and cover. Higher variation in stream width and depth improved vegetation outcomes. Bank incision had a clear negative relationship with amphibious vegetation but not for fully aquatic species. Similarly, the magnitude of wet weather flows also displayed a negative relationship with amphibious vegetation, however, this was less clear for aquatic species. Importantly, we found that there is a limit to which increasing geomorphic complexity can improve instream vegetation, without also addressing the hydrological impacts of stormwater runoff (see Figure 1). The outputs from this project are improving our understanding of how alterations to catchment hydrology effect the distribution and composition of instream vegetation to help inform future target setting and management priorities for instream vegetation.

Considerations for implementation:

- Incorporate the inclusion of instream vegetation cover into the HWS MERI physical form and biological monitoring programs.
- Include rapid and relevant vegetation monitoring metrics into regular monitoring programs such as: presence/ absence of plant functional groups, morphotypes or species level data.
- Provided that flood frequency is addressed, measures that restore stream bank incision and promote greater depth variation (such as the use of large wood which encourages

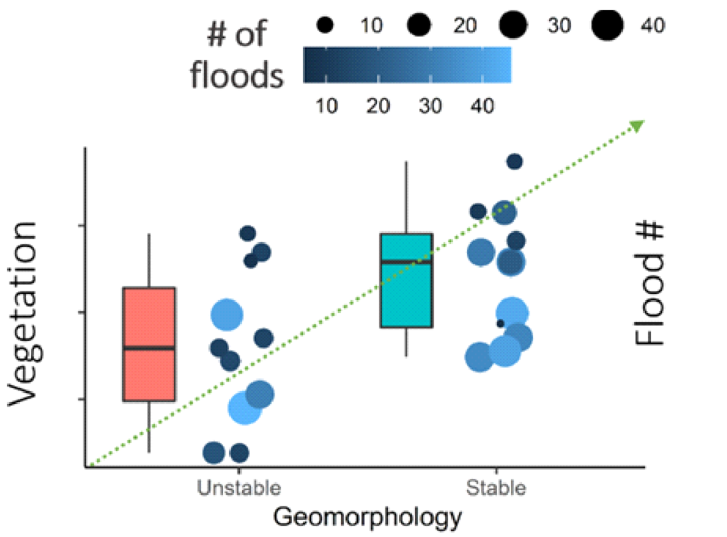

Figure 1. The interaction between geomorphic complexity (boxplots) and flood frequency (points). Amphibious vegetation richness is shown here as an example of this interaction. The green arrow represents the trend in vegetation responses as both

pioneer geomorphic features e.g. bars), would increase colonisation of amphibious vegetation and further aid the development of feedback effects which restore geomorphic complexity.

What did we do?

The project seeks to investigate critical pathways and feedback cycles between flow, organic matter and instream vegetation. This research is being undertaken using a staged approach, beginning with the following:

- Identify key instream vegetation preferences based on site-scale and micro-scale geomorphic complexity and flow variables.
- Identify key geomorphic variables that drive instream vegetation richness, diversity and cover.
- Identify characteristics of the flow regime that explain relationships with instream vegetation richness, diversity and cover.
- Identify characteristics of the flow regime that explain relationships with instream vegetation emergence and community composition.
- Investigate the role of aquatic vegetation as ecosystem engineers through trapping fine sediment and seeds.

In 2021 we undertook a large-scale survey of 23 sites spread across the Greater Melbourne Region. We selected up to 10 cross sectional transects across a 100m reach, and placed quadrats along each transect, recording the percentage cover of: (a) substrata; (b) retention features, e.g. boulder, wood, backwaters; (c) retained vegetative fragments or other CPOM based on Bovill et al. (2020). All instream vegetation along the transect was identified to the lowest taxonomic level possible. We also calculated a range of geomorphic and flow indices for each site including: median annual discharge, number of floods and rate of change (metrics related to flashiness) and further flow metrics (e.g. Riis et al. 2008); and variation in stream depth, stream width, substrate size, bank incision and instream wood (e.g. Polvi et al. 2014).

Sediment was also collected at seven sites for a propagule bank trial aimed at investigating aquatic vegetation as an ecosystem engineer i.e. as a retentive feature within the stream channel that traps instream vegetation propagules and fine sediment, resulting in the potential for changes to the physical form of stream ecosystems.

What did we find?

Stream complexity and flow regime in relation to instream vegetation

- Aquatic vegetation communities benefit from increasing variation in stream depth, and possibly width, likely due to an increase in available habitat niches.
- Increasing flood frequency (flashiness) may decrease aquatic cover through biomass removal, however, richness and diversity were not significantly influenced; meaning aquatics may be able provide some ecological benefits in degraded streams and improve as catchment scale hydrological stressors are addressed (i.e. flashiness).
- Amphibious species richness and diversity is negatively affected by bank incision, likely due to a lack of a depth gradient along the banks hampering deposition and colonisation.
- Flashiness also has a strong negative relationship to amphibious cover, possibly influencing colonisation along with biomass removal.
- Catchment scale hydrological stressors (e.g. flashiness) clearly reduced aquatic cover and amphibious richness, diversity and cover in more geomorphically stable western plains sites; but not in less stable eastern uplands sites, where geomorphology was more degraded. This suggests there is ultimately a threshold in which enhanced geomorphic complexity can improve instream vegetation if catchment scale hydrological stressors are not also addressed (Figure 1).
- After grouping sites into unstable, simplified sites (mostly in the eastern uplands) and stable, complex sites (mostly in the western plains), significantly higher richness and cover of amphibious species was found in the stable sites with clearly distinct communities from that of the unstable sites.

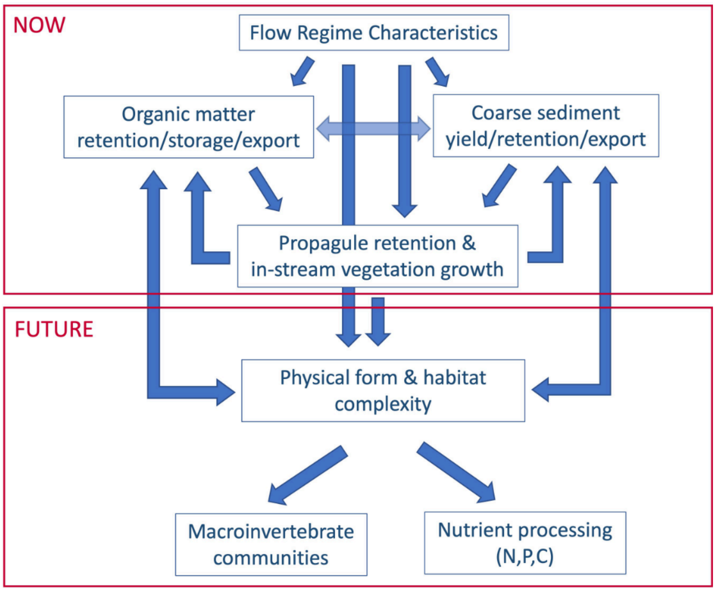

Figure 2. Hypothesised conceptual model of interest, showing mapped research questions

Future direction and Knowledge gaps

This project investigated geomorphic and flow relationships with instream vegetation using high resolution data at the within-site scale (Figure 2). Larger scale, site level datasets should be used where available to test the outcomes from the current studies and solidify knowledge and conceptual models.

Analysis is currently underway on site-level data of 82 sites surveyed for instream vegetation in the summer/autumn of 2024 across the Port Phillip and Westernport region. Data from the VegVisions project also offers coarser data on instream plant lifeform distributions across the same region. Once a greater understanding of the drivers of instream vegetation are established, future research should investigate relationships and feedback cycles between instream vegetation and stream geomorphology (i.e. ecosystem engineering), nutrient processing and stream biota (Figure 2).

How are we sharing findings?

- MCKENDRICK, S. A., GREET, J., IMBERGER, M., & BURNS, M. J. (2024). Catchment-scale hydrology limits the benefits of geomorphic complexity for instream vegetation communities. Ecological Engineering, 200, 107176. doi: https://doi.org/10.1016/j.ecoleng.2023.107176
- MCKENDRICK, S. A., BURNS, M. J., IMBERGER, M., RUSSELL, K. L., & GREET, J. (2024). Riverine aquatic plants trap propagules and fine sediment: Implications for ecosystem engineering and management under contrasting land uses. Earth Surface Processes and Landforms.

For more details on the research outcomes of this project, or other projects of the MWRPP, please contact:

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References

- BOVILL, W. D., DOWNES, B. J. & LAKE, P. S. 2020. A novel method reveals how channel retentiveness and stocks of detritus (CPOM) vary among streams differing in bed roughness. Freshwater Biology.
- POLVI, L. E., NILSSON, C. & HASSELQUIST, E. M. 2014. Potential and actual geomorphic complexity of restored headwater streams in northern Sweden. Geomorphology, 210, 98-118.
- RIIS, T., SUREN, A. M., CLAUSEN, B. & SAND-JENSEN, K. A. J. 2008. Vegetation and flow regime in lowland streams. Freshwater Biology, 53, 1531-1543.